FISHERY RESEARCH

Natural Production Monitoring and Evaluation

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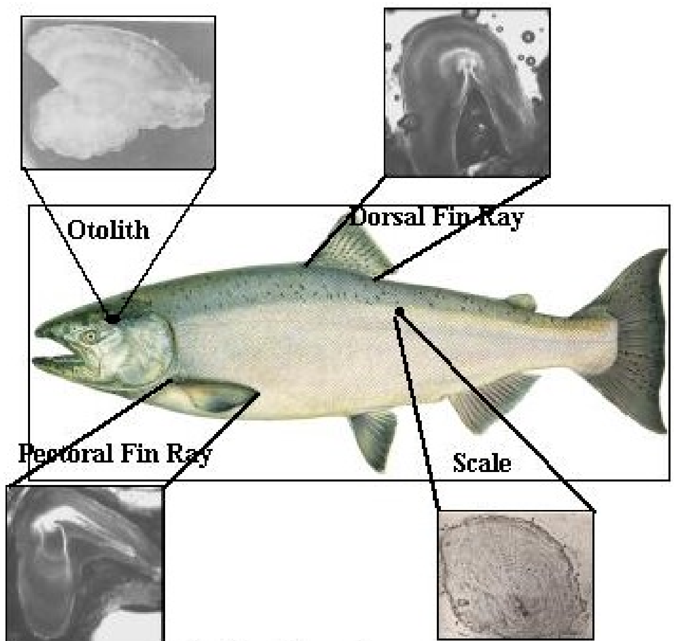

Aging Structures

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IDFG Report Number 01-41
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Natural Production Monitoring and Evaluation

Part 1—Monitoring age composition of wild adult spring and summer chinook salmon returning to the Snake River Basin.

Part 2—Developing a stock-recruitment relationship for Snake River spring/summer chinook salmon to forecast wild/natural smolt production.

Part 3—Improve wild steelhead smolt-to-adult survival rate information by PIT-tagging additional wild steelhead juveniles.

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PART 1—MONITORING AGE COMPOSITION OF WILD ADULT SPRING AND SUMMER SALMON RETURNING TO THE SNAKE RIVER BASIN.

ABSTRACT

This report covers efforts to monitor age composition of wild adult spring/summer chinook salmon returning to the Snake River Basin. Accurately determining the ocean age proportions of wild adult spring/summer chinook salmon is important information for monitoring the status and trends of these species. During this report period, project personnel selected the preferred structure for aging, set up a database to track all samples collected, developed procedures and ordered equipment for structure preparation and reading, and aged the adults that were sampled in 1999. Chinook salmon carcasses were sampled from representative spawning areas throughout the Snake River Basin. Ocean age proportions were determined for each 5 centimeter fork length group for wild adult spring/summer chinook salmon returning to the Snake River. These ocean age proportions were applied to the number and estimated length frequency distribution of wild chinook salmon adults passing Lower Granite Dam to estimate the number of adult returns for each ocean age group.

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INTRODUCTION

Accurate age information is important for the successful management and recovery of wild Snake River spring/summer chinook salmon *Oncorhynchus tshawytscha*. Pacific salmon *Oncorhynchus sp.* are usually aged by examining the circuli of scales. However, as Pacific salmon leave the ocean for their spawning migration, they cease feeding and scale material is resorbed. This resorption results in the loss of circuli and annuli on the periphery of scales, making accurate age determination difficult if not impossible for salmon with long spawning migrations such as Snake River spring/summer chinook (Chilton and Bilton, 1986). During the fall of 1998, a variety of aging structures (scales, otoliths, dorsal fins, and pectoral fins) were collected from wild spring/summer chinook salmon carcasses to determine which structure was most suitable to meet project objectives. In spring 1999, Idaho Department of Fish and Game (IDFG) personnel transported these aging structures to the aging lab at Canada's Pacific Biological Station in Nanaimo, British Columbia and were provided training in sample preparation, structure aging, and aging data management. After this training and further consultation with Shayne MacLellan and her staff at the Pacific Biological Station, it was determined that dorsal fin rays were the aging structure most suited to meet project objectives. This report covers project efforts to set up an aging fin preparation and reading lab, develop a database to track all salmon and steelhead biological samples collected by IDFG, collect aging structures from all major spring/summer chinook salmon spawning areas in the Snake River Basin, and report results from samples collected in 1999.

STUDY AREA

The study area encompasses all streams in the Snake River Basin upstream of Lower Granite Dam (LGD) that are currently accessible to wild spring/summer chinook salmon (Figure 1). In 1999, carcasses from major spawning areas in the Snake River Basin (Figure 1) were sampled. Because of the very low numbers of returning wild spring/summer chinook salmon adults in 1999, carcasses were not collected from some of the major production areas.

METHODS

Sampling

Training and instructions to help ensure correct sample collection and data recording were provided in several forms. A spawning survey manual and video were produced and distributed that illustrate the proper techniques and procedures. Additionally, on-site training was provided at the Nez Perce Tribe's redd count training, Sawtooth Hatchery, and the interagency redd count training on Marsh Creek.

Several structures were collected from carcasses for age and DNA analysis. A dorsal or pectoral fin (aging fin) and scales were collected for age analysis. A small piece of fin tissue was also collected for DNA analysis.

Aging fins were collected using a serrated knife. The aging fin is held at a 90-degree angle to the body and is removed by making a cut level with the body of the fish. The aging fin is then inserted into a coin envelope with the fin base exposed and the fin rays aligned perpendicular to the fin base.

Five scales from the preferred area of each side of the fish were collected with forceps and carefully placed rough side up on gummed paper. The preferred area for scale collection is an oval centered five scales above the lateral line on a diagonal from the posterior edge of the dorsal fin to the anterior edge of the anal fin. The scales were collected for the potential to develop scale resorption criteria for Snake River chinook salmon at a later date.

A small pencil eraser sized piece (approximately 4 mm^2) of fin with good color was collected from each carcass sampled and placed in a test tube filled with 95% alcohol. These tissue samples were catalogued and stored for future DNA analysis.

All samples from an individual fish were placed in a Zip-lock® bag and sealed. All samples were transported to the IDFG Fisheries Research Office in Nampa, Idaho, catalogued, and stored for later analysis. The aging fins were stored in a freezer until prepared for aging.

The majority of samples were collected on the spawning grounds from wild adult carcasses that had died naturally. Wild adult samples were also collected from the small percentage of wild adults captured and spawned at several of the chinook salmon hatcheries in Idaho and from wild adult carcasses that floated down to the front of adult trapping weirs. Aging fins and scales were collected from known-age hatchery adults that returned to Sawtooth, Rapid River, and Dworshak hatcheries to estimate the accuracy of the aging methods.

Data Storage

Project personnel developed a Microsoft® Access® database to catalogue and interrelate all biological samples collected. While adding complexity and development time to the database needed for this project, one complete database will increase the overall efficiency of these research projects and provide better access to information and sample tracking. Currently the database is available to IDFG researchers.

Fin Preparation

To begin fin preparation, a workable sample of chinook dorsal fins (approximately 25-30) was removed from the freezer where they had been stored. Each individual envelope containing a dorsal fin was placed upright in specially designed wooden racks that keep the fins separated and allow air circulation, permitting the fins to dry thoroughly. After drying, fins were brushed clean of debris. Excess materials (i.e. bones, loose skin, and flesh) and unneeded fin rays were removed. The fins were then individually coated in a 2-3 mm thick layer of epoxy and placed on waxed paper to harden overnight. After the epoxy hardened, excess was trimmed from the fin margins, and the respective sample number was written on each fin. Throughout the entire fin preparation process, utmost care was taken to maintain the respective identity (sample number) of each fin.

Slicing fins into cross-sections was the next step of fin preparation. This step is important in that it requires both practice and precision to produce cross-sections that can be aged with a compound microscope. Multiple sections were obtained from each individual fin using a water-cooled Bronwill® diamond grit bone saw. This saw features a moving carriage and metered hand wheel that allowed great precision in obtaining cross-sections of exact thickness. To begin slicing, a prepared fin was clamped into a pair of vise-grips® that were then locked in a chuck on the moving carriage. The moving carriage was switched on and it carried the fin to a 0.32 mm diamond grit blade. The hand wheel was used to adjust the thickness of the slices to 1.3–1.5 mm. With the carriage controls, a fin was sliced, repositioned for desired thickness, and resliced until an average of 10–12 cross-sections were obtained. Cross-sections were then dried and affixed onto microscope slides using a clear liquid mounting medium that improves resolution and preserves the sample. The cross-sections from one fish usually do not fit on one slide, so in addition to the sample number, a slide letter was also written on each slide with a permanent marker in order to maintain the order in which the slices were cut. For example, the first set of slices from fish 99-199 would be placed on the first slide, which would be labeled 99-199A. The next slide would be 99-199B and so on until all sections were mounted on slides.

Fin Aging

Fins were aged with the use of a compound microscope and green filtered transmitted light. Light passing through the individual fin ray sections illuminated wide opaque zones alternating with narrower translucent zones. Opaque zones represent material deposited during the summer period of rapid growth, and translucent zones represent material deposited during the winter period of slow growth (Ferreira, et. al. 1999). The winter translucent zones (annuli) were counted to age the fish. The annuli are developed from the center outward as the fish and the fin ray grows. Snake River wild spring/summer chinook usually spend one winter in the freshwater rearing areas before smolting and migrating to the ocean. The kidney shaped freshwater annulus is near the center of the fin ray. With the very cold Snake River Basin winters, the freshwater annulus translucent zone is narrow and fairly bright (Figure 2). Because ocean winters are not nearly so cold and some growth does occur, the ocean annuli are broader and usually not nearly as bright as the freshwater annulus (Figure 2).

A reference collection of known age fins (from hatchery PIT-tagged and coded wire-tagged adult returns) was developed to assist in reader training and for a mandatory practice session if the employee had not aged fins during the past month. All samples aged were independently read by at least two employees trained in fin aging techniques. Three employees independently read fin samples from fish with fork lengths in the range of significant ocean age overlap. If there was disagreement in age determination or the determined age did not match what is normal for the fish's length, that fin was read again in a referee session. During a referee session, a camera was attached to the microscope and the image was displayed on a computer screen. Three trained employees then viewed the fin together and determined the fish's age if possible. In a few cases, fin samples were unreadable.

Ocean Age Proportions at Lower Granite Dam

Video monitoring was used to determine the length frequency of adult wild chinook salmon passing LGD. From May through August, videos recorded adults passing the viewing window at LGD for 24 hours on every third day. The initial start date for recording videos was randomly selected; this random start date established the video recording schedule for the rest of the season. At the end of adult migration season, the videotapes were shipped to the IDFG

Nampa Research Office for analysis. Each video was viewed every fourth hour for images of adults passing the viewing window at LGD. Which fourth hour to view was randomly selected for each videocassette tape. The video images of each adult observed passing the viewing window were examined for the presence of an adipose fin. For those adults determined to be wild (adipose fin present), one image was digitized for length analysis. A small percentage of adult returns with an adipose fin present were actually hatchery fish (missed clips or other marks besides adipose fin clip) that could not be determined from the video images. Video editing software was used to calculate the ratio of each adult's image fork length to the image length of vertical lines placed on the viewing window. Video images of measuring sticks of known lengths (62 cm, 85 cm, and 100 cm) were also digitized and image length ratios to the viewing window vertical lines were calculated. The image ratios from the measuring sticks were used to develop a regression between image length ratios and actual lengths. This regression was used to estimate the actual fork length from the digitized images of the wild adults passing LGD. A length frequency distribution for wild adults passing LGD was developed with these estimated actual fork lengths. The estimated ocean age proportions for each 5 cm length group developed from the fin aging work was applied to this length frequency distribution to estimate the ocean age proportions of all wild adults passing LGD in 1999.

RESULTS AND DISCUSSION

Known Age Hatchery Adults

Aging fins were collected from 25 known age hatchery adult returns in 1999. Fins from these known age fish were prepared and aged first to test our methodologies and accuracy. We aged 22 (88%) of these adults correctly. As a group, we reviewed the known age fins that were not correctly aged. All three of these fins had a single ocean annulus that was split into two parts in some of the cross sections and had been identified as two separate annuli. Our aging training was adjusted to include reviewing the differences between a split annulus and two separate annuli. With this adjustment to our methodologies, we believe the 88% accuracy rate to be a minimum for the wild adults.

Wild Adult Carcass Age Determinations

We examined fin ray cross sections from 281 wild adult carcasses collected in 1999, determined the ocean age for 266 of these adults, and classified the remaining 15 as unreadable. The fork lengths and ocean age determinations for the 266 wild adult carcasses aged are displayed in Figure 3. The ocean age proportions for these 266 carcasses were 0.086 1-ocean, 0.729 2-ocean, 0.157 3-ocean, and 0.026 4-ocean. The ocean age proportions for each 5 cm fork length group were calculated from these results (Table 1). Because surveyors are more likely to find larger carcasses, we must caution that the ocean age proportions of the carcasses we collected and aged are not necessarily the same as the ocean age proportions of the entire population.

Estimated Ocean Age Proportions of Wild Adults Passing LGD

We digitized the video images of 447 wild adults passing through the viewing window at LGD. With these images we developed an estimated fork length frequency distribution for the population of wild adults passing LGD in 1999 (Figure 4). With the length frequency distribution (Figure 4) and the estimated ocean age proportions for each length group (Table 1), we estimated the ocean age proportions of wild adults passing LGD in 1999 to be: 0.082 1-ocean, 0.743 2-ocean, 0.152 3-ocean, and 0.022 4-ocean. There were an estimated total of 2,919 wild adults (excluding jacks) passing LGD in 1999 (TAC, 2000). We used this estimated number of adults (excluding jacks) and the estimated proportion of jacks from our analysis to estimate the total number of wild adults and jacks that passed LGD in 1999 to be 3,180 [2,919 / (1 - 0.082) = 3,180]. We therefore estimated that there were 261 1-ocean, 2,363 2-ocean, 483 3-ocean, and 73 4-ocean wild spring/summer chinook salmon adults that passed LGD in 1999.

ACKNOWLEDGMENTS

We would like to gratefully acknowledge several agencies and the large number of people without whom we would not have been able to accomplish this work. We are grateful to the Bonneville Power Administration and our contracting officer Tom Vogel for their support and funding of this research. We thank Steve Richards and his crew with the Washington Department of Fish and Wildlife in helping us set up the video schedule and protocols and for operating the video cameras for this work. We thank the U.S. Army Corps of Engineers for allowing us to conduct the video work at Lower Granite Dam. Special thanks go to the many folks working for the Nez Perce Tribe, the Shoshone-Bannock Tribes, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, U.S. Forest Service, and other IDFG projects for collecting the aging fins and associated carcass data. We are very grateful to Shayne MacLellan and her staff at the Pacific Biological Station in Nanaimo, B.C. for the large amount of assistance they provided in determining what structure was most suitable for our needs and providing us hands-on training on collecting, preparing, reading, and managing aging data. We thank the Columbia River Inter-Tribal Fish Commission for loaning the video editing equipment used to digitize the video images. Joseph R. Tomerelli was gracious enough to allow us to use his artwork.

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Table 1. Estimated ocean age proportions by 5 cm fork length groups for Snake River wild/natural spring/summer chinook salmon adult carcasses sampled in 1999.

Length group (cm)	1-Ocean	2-Ocean	3-Ocean	4-Ocean	n
<65	0.96	0.04	0	0	24
65-69	0.33	0.67	0	0	3
70-74	0	0.95	0.05	0	19
75-79	0	0.99	0.01	0	73
80-84	0	0.96	0.04	0	68
85-89	0	0.79	0.21	0	29
90-94	0	0.31	0.58	0.12	26
>94	0	0.04	0.78	0.17	23

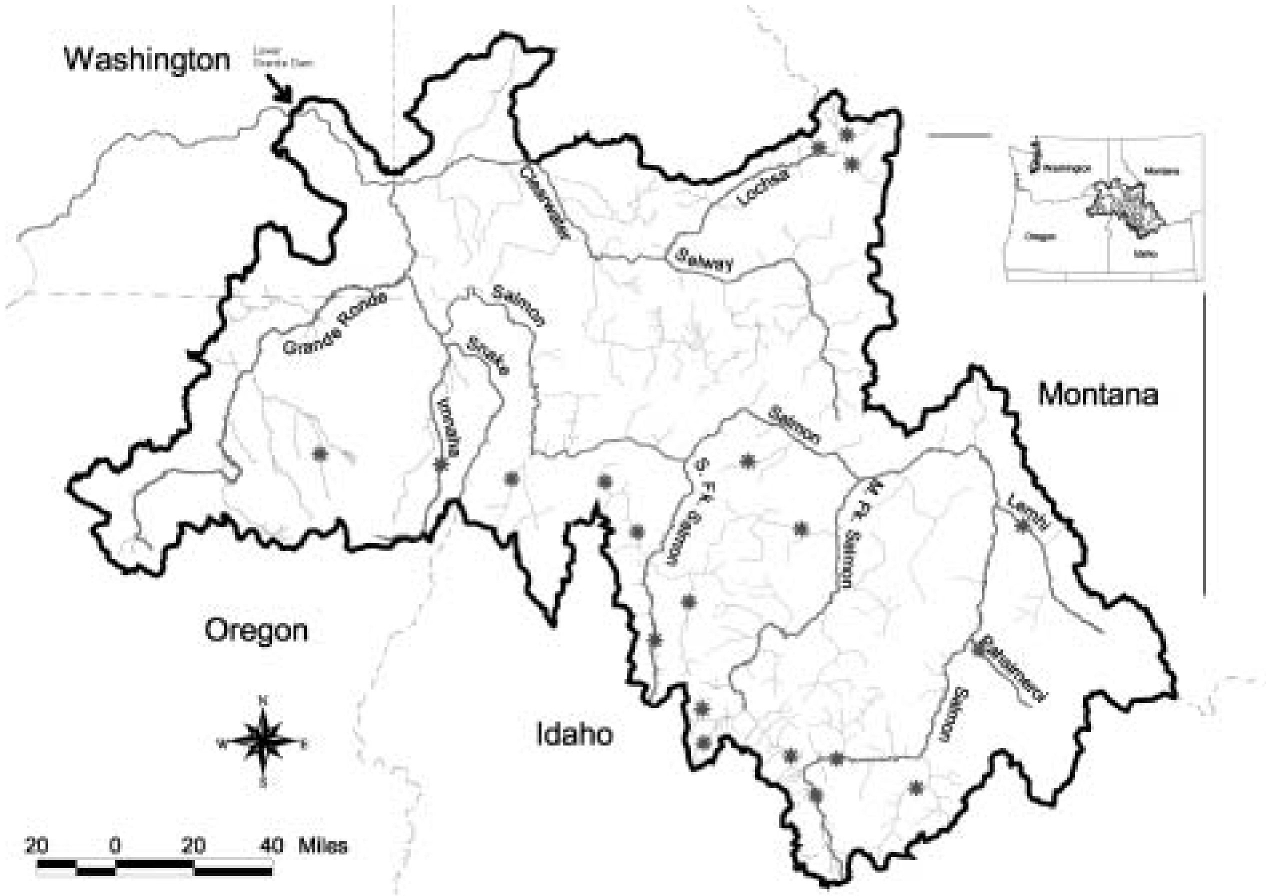

Figure 1. Snake River Basin study area and spawning streams from which wild/natural spring/summer chinook salmon adult carcass aging fins were collected in 1999.

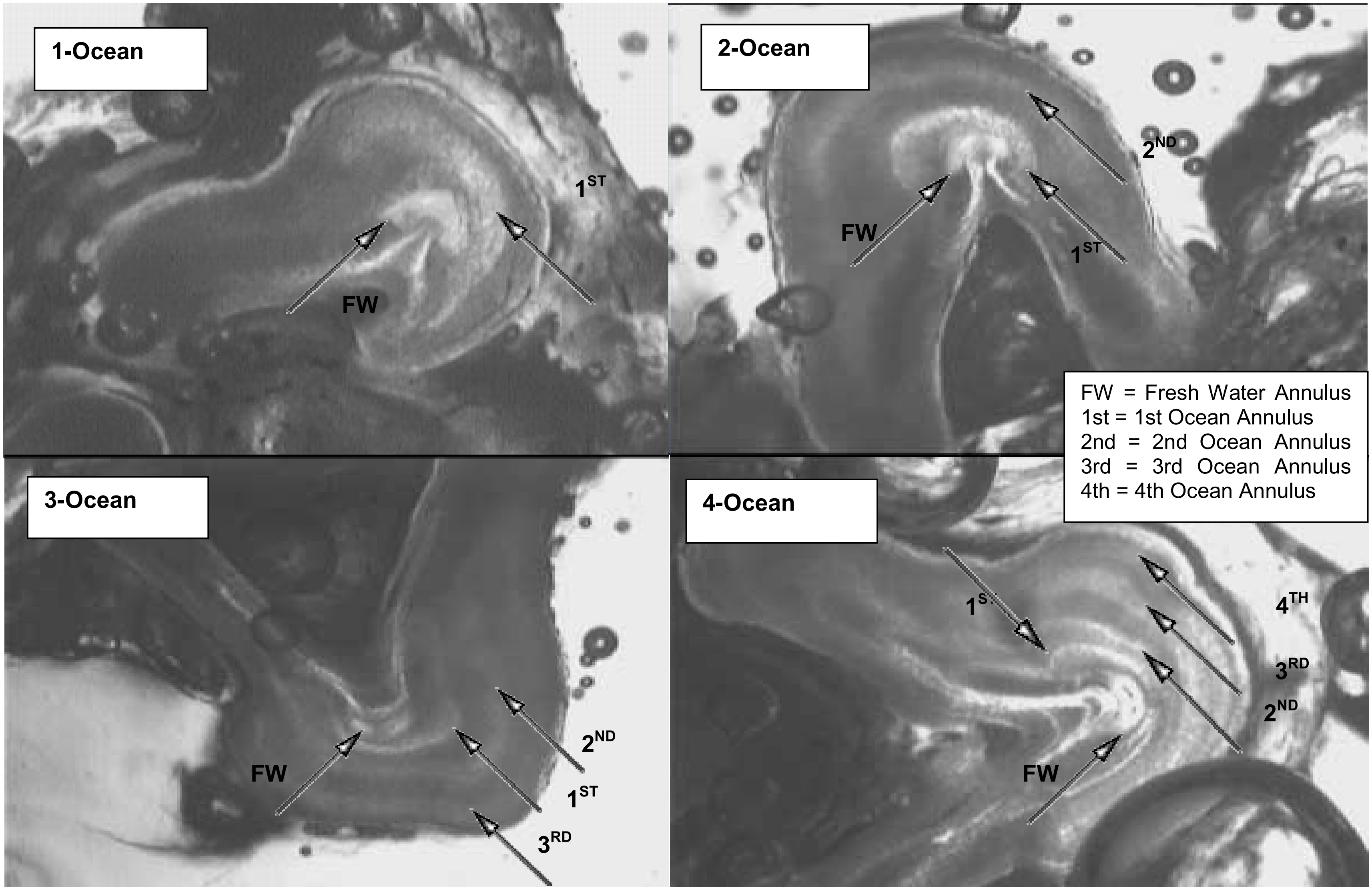

Figure 2. Representative dorsal fin ray cross sections from the four different ocean ages observed for Snake River wild/natural spring/summer chinook salmon adult returns in 1999.

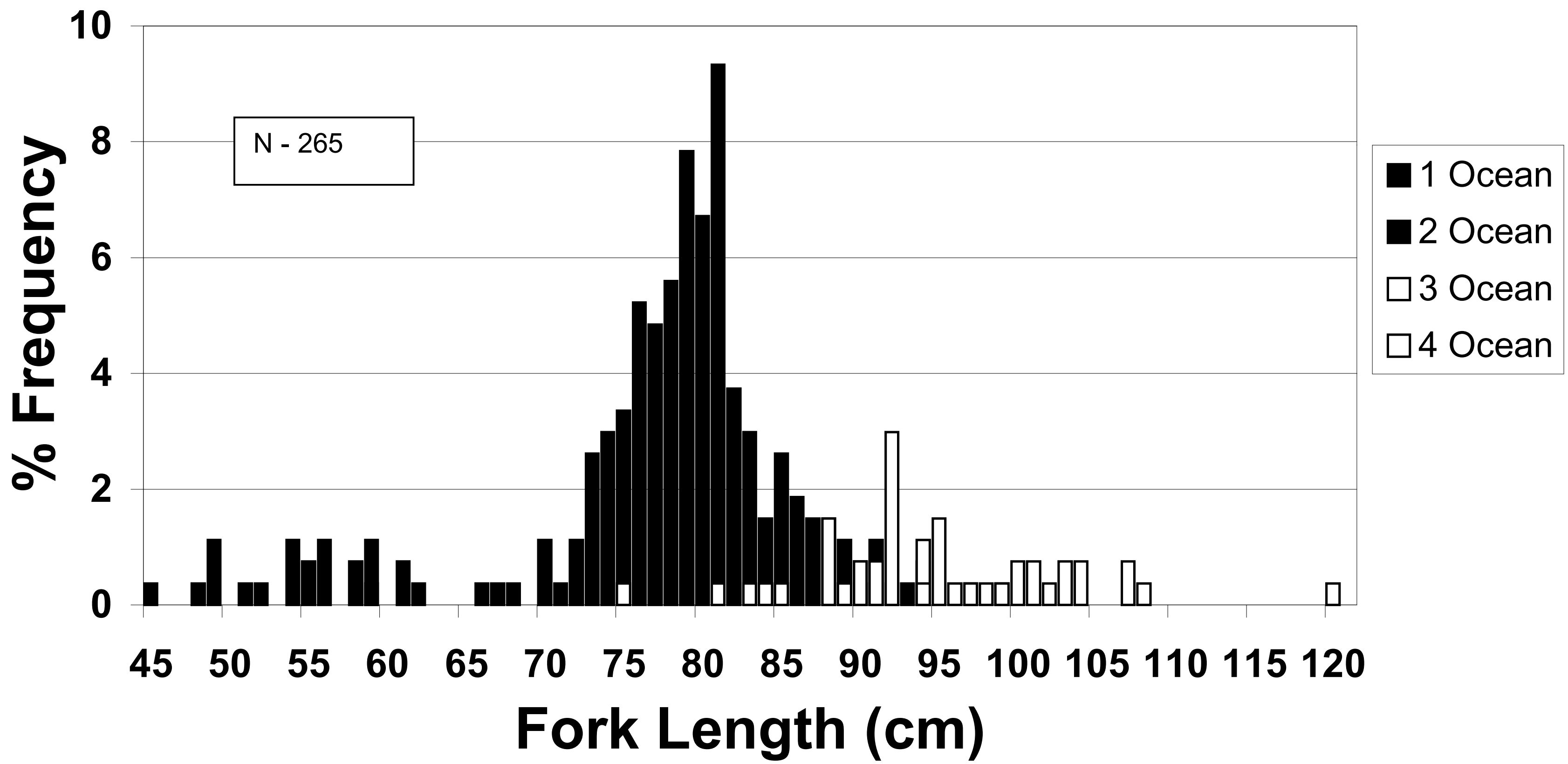

Figure 3. Snake River wild/natural spring/summer chinook carcass fork lengths and ocean ages determined from fin cross sections.

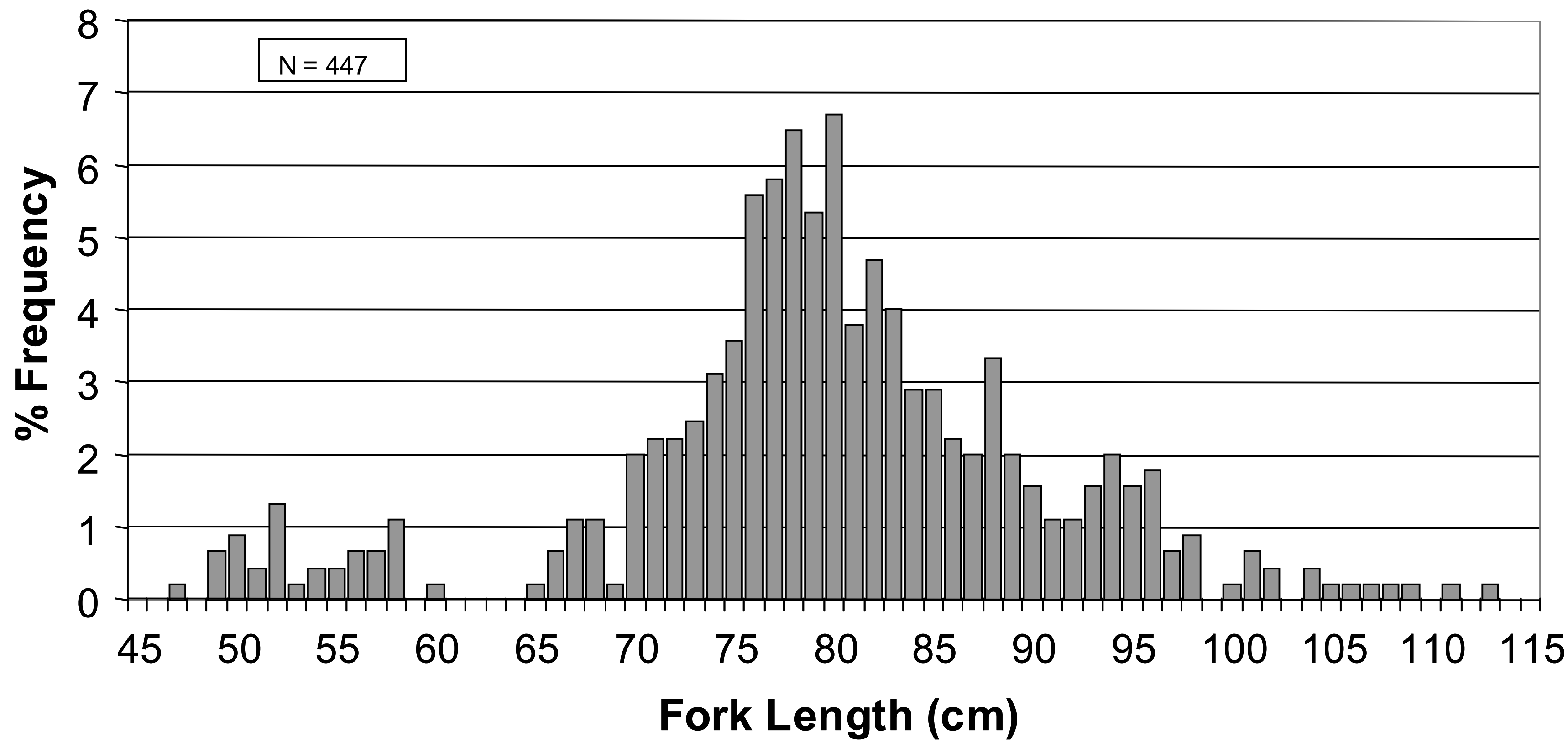

Figure 4. Estimated length frequency distribution for Snake River wild/natural spring/summer chinook salmon adults passing Lower Granite Dam in 1999.

PART 2—DEVELOPING A STOCK RECRUITMENT RELATIONSHIP FOR SNAKE RIVER SPRING/SUMMER CHINOOK SALMON TO FORECAST WILD/NATURAL SMOLT PRODUCTION.

ABSTRACT

A stock-recruitment relationship for Snake River spring/summer chinook salmon *Oncorhynchus tshawytscha* was derived by estimating females available for natural reproduction (parents) and resulting wild/natural smolt production (recruits). This stock-recruitment relationship was developed from data collected at Lower Granite Dam from brood years 1990-1998. I assumed the stock-recruitment relationship would be in the form of a Beverton-Holt function and plotted the following model:

$$recruits = \frac{1}{5.49098E-07 + 0.02592286 / parents}$$

Due to low escapement during the analysis period, the asymptote of the stock-recruitment function could not be defined.

Smolts per female production ranged from 92 to 406, with a mean of 243 smolts/female. A linear regression was developed between females available for natural reproduction and the natural log transformation of smolts/female. This regression was used to forecast the number of brood year 1999 wild/natural smolts that will emigrate during the 2001 smolt migration season. For brood year 1999, I estimated females available for natural reproduction to be 1,594. Based on the regression model [natural log smolts/female = -0.0001 (females available for natural reproduction) + 5.8736], those females will produce 478,200 smolts (90% CI of 269,386 - 840,038).

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INTRODUCTION

Survival during both fresh and saltwater life stages for Snake River spring/summer chinook salmon must be well understood for decision makers to implement recovery measures that have a reasonable probability of contributing to recovery. An important tool to aid in understanding freshwater survival for anadromous fish is to develop stock-recruitment relationships that span the critical period of freshwater residence when density-dependent mortality defines the shape of the relationship (Solomon, 1985). I developed a stock-recruitment relationship between the number of female adult spring/summer chinook salmon passing Lower Granite Dam (LGD) that were available for natural reproduction (FANR) and the resulting number of wild/natural smolts arriving at LGD one and a half years later.

This stock-recruitment relationship allows for evaluating freshwater survival on a basinwide scale (Figure 5). Smolt abundance at LGD was selected as the index of recruitment for two main reasons: First, smolts are the last life stage that encompasses all density dependent mortality before the highly variable survival factors of mainstem migration conditions and ocean productivity. Secondly, smolts are the freshwater life stage for which abundance can be most accurately estimated on a Snake River Basin-wide scale. An additional advantage to this approach is that a stock-recruitment relationship derived on a basin-wide scale will yield a curve reflecting the balance of good and sub-optimal habitat in the basin (Crozier and Kennedy, 1995).

The stock-recruitment relationships for Columbia River Basin chinook salmon are assumed to be in the form of a Beverton-Holt function (NPPC 1986), or a Ricker function (Petrosky et. al, 2001). In a Beverton-Holt function, the relationship is regulated by density dependent mortality and hyperbolic in shape, with the asymptote representing carrying capacity (Beverton and Holt, 1957). In a Ricker function, a regulatory mechanism such as greater density increasing the time needed for juveniles to grow through a particularly vulnerable size range causes declines in recruitment at higher stock densities (Ricker, 1975).

To forecast brood year 1999 smolt production I adapted the methods described by Chadwick (1982). We used FANR as our independent variable to regress against the dependent variable of natural log transformation (ln) of smolts/female production. This regression allows for directly evaluating the relationship between spawner density and smolts/female productivity, as well as forecasting a mean and confidence interval for next springs smolt production (Chadwick, 1982). Another statistic of interest from this regression (the y-intercept) is the estimate of mean density-independent rate of reproduction in units of smolts/female (Chadwick, 1982).

METHODS

Females Available for Natural Production

The estimated number of adult spring and summer chinook salmon (excluding jacks) passing LGD in 1999 were obtained from the Fish Passage Center website (http://www.fpc.org/adult_history/YTD-LGR) accessed on December 12, 2000. The total number of male (excluding jacks) and female spring and summer chinook salmon captured at all

Snake River hatchery traps and the number of females taken into hatcheries were obtained from unpublished hatchery run disposition data (Jeff Abrams, Idaho Department of Fish & Game, personal communication), (Pat Keniry, Oregon Department of Fish & Wildlife, personal communication), and (Ralph Roseburg, U.S. Fish & Wildlife Service, personal communication). For each run of chinook salmon (spring or summer) the percentage of females captured at hatchery traps were applied to the LGD counts to estimate the total number of female chinook salmon passing LGD. The number of females taken (spawned, culled, or prespawning mortalities) in the hatcheries was adjusted for 20% migration mortality (Ted Bjornn, University of Idaho, personal communication). To estimate the number of FANR, the adjusted hatchery female number and the estimated number of females harvested upstream of LGD were subtracted from the estimated number of females crossing LGD. The brood year 1999 numbers of female spring and summer chinook salmon available for natural reproduction were combined to estimate total number of FANR.

Smolt Production

Smolt production was estimated using fish passage data collected at LGD. Daily smolt abundance was estimated by dividing the daily counts of smolts collected by that day's estimated collection efficiency. The number of wild/natural chinook salmon smolts collected daily at LGD was obtained from the Fish Passage Center website (http://www.fpc.org/SMPDATA.html), accessed on December 12, 2000. The daily smolt collection efficiencies at LGD were estimated by this project (Kiefer et al., in progress) for migratory years 1992-1996 and by Steve Smith (National Marine Fisheries Service, personal communication) for migratory years 1997-2000. For each brood year (1990–1998), I estimated smolts/female production by dividing total smolt production by FANR.

Stock-Recruitment Relationship

I assumed that the adult-to-smolt stock-recruitment relationship for Snake River spring/summer chinook salmon would be in the form of a Beverton-Holt function (Beverton and Holt, 1957). This assumption is based on our belief that the regulatory mechanism for Snake River spring/summer chinook salmon smolt production is more likely to be a ceiling of abundance imposed by available food or habitat rather than greater density increasing the time needed by young fish to grow through a particularly vulnerable size range (Ricker, 1975). However, both Ricker and Beverton-Holt relationships produce similar curves in the lower range of adult escapements that I have data for. To develop a stock-recruitment relationship for these fish, I regressed FANR for brood years 1990-1998 against the associated smolt production. I used the Beverton-Holt formula:

$$R = \frac{1}{\alpha + \beta / P}$$

as described by Ricker (1975) as formula 11.20.

Smolt Production Forecast

A linear regression was developed between FANR and the resulting ln(smolts/female) production. The estimated number of brood year 1999 FANR was applied to this regression to forecast a mean and 90% CI of smolts/female production. This smolts/female forecast was multiplied by the estimated number of FANR to forecast the number of wild/natural smolts that will arrive at LGD in spring 2001.

RESULTS AND DISCUSSION

Females Available for Natural Production

The estimated number of adult spring and summer chinook salmon (excluding jacks) passing LGD in 1999 was 6,556, and for return years 1990–1998 ranged from a low of 1,799 to a high of 44,565 (Table 2). The estimated female proportions of adults (excluding jacks) captured at Snake River hatchery traps were estimated separately for spring and summer chinook salmon (Table 3). These estimated female proportions (0.478 spring chinook salmon and 0.487 summer chinook salmon) were applied to the estimated number of adults passing LGD for both runs to estimate 1,539 female spring chinook salmon and 1,588 female summer chinook salmon passing LGD in 1999 (Table 2). After accounting for females taken into the hatcheries (adjusted for 20% migration mortality) and harvest, I estimated that 791 female spring chinook salmon and 803 female summer chinook salmon were available for natural reproduction. I therefore estimated combined brood year 1999 FANR for Snake River spring and summer chinook salmon to be 1,594.

Smolt Production

For brood years 1990–1998, estimated smolt production ranged from 161,157 to 1,558,786 (Table 2). During this period, smolts/female production averaged 243 smolts/female, and ranged from 92-406 smolts/female (Table 2).

Stock-Recruitment Relationship

The stock-recruitment relationship for Snake River spring/summer chinook salmon is shown in Figure 6. Smolt production was significantly correlated with FANR [$P < 0.01$]. Although fairly short, covering only nine brood years, this data series appears sufficient to reasonably define the shape of the curve at lower adult escapements. Even with the current depressed status of adult returns, this stock-recruitment relationship indicates density dependent mortality. Adult returns have been too low to determine if the type of relationship is a Beverton-Holt function (Beverton and Holt, 1957) or a Ricker function (Ricker, 1954).

Smolt Production Forecast

The linear regression between FANR and the ln(smolts/female) production indicates a correlation between spawner density and smolts/female production (Figure 7). Even with the current depressed status of Snake River adult escapements, increased spawner density apparently results in lower smolts/female productivity. Another statistic of interest from this regression (the y-intercept) is the estimate of mean density-independent rate of reproduction (356 smolts/female). We estimated brood year 1999 FANR to be 1,594. Based on the regression model [ln(smolts/female) = -0.0001(FANR) + 5.8736], this escapement will produce a mean of 300 smolts/female with a 90% confidence interval of 169 – 527 smolts/female (Figure 7). I therefore forecast that in migratory year 2001, the number of wild/natural smolts that will arrive at LGD will be 478,200 with a 90% confidence interval of 269,386 – 840,038. The upper 90% confidence interval of smolts/female production (527) is much higher than the highest estimate of smolts/female production (406) from the nine brood years for which I have data. This apparently high smolts/female upper bound is a result of the low brood year 1999 escapement and the variability of the regression model.

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Table 2. Brood year 1990-1998 Snake River spring/summer chinook salmon estimates of natural smolts per female production and brood year 1999 estimate of females available for natural reproduction.

Brood Year	**1990**		**1991**		**1992**		**1993**		**1994**	
Run	**Spring**	**Summer**	**Spring**	**Summer**	**Spring**	**Summer**	**Spring**	**Summer**	**Spring**	**Summer**
Dam Counts	17315	5093	6623	3809	21391	3014	21035	7889	3120	795
% Females	48	44	44	52	49	43	55	55	55	60
# Females	8368	2246	2906	1961	10482	1294	11535	4340	1706	478
# Females in Hatcheries	3395	421	1330	252	2747	462	4861	528	686	164
Adjustment for Migration Mortality[a]	4244	526	1663	350	3434	578	6076	660	858	205
# Females in Harvest	796	10	1	0	897	43	658	0	83	5
Female Escapement	3328	1710	1292	1611	6151	673	4801	3680	765	268
Combined Female Escapement	5038		2853		6824		8481		1033	
Combined w/n Smolts	527000		627037		627942		1558786		419826	
# Smolts per Female	105		220		92		184		406	

Brood Year	**1995**		**1996**		**1997**		**1998**		**1999**	
Run	**Spring**	**Summer**	**Spring**	**Summer**	**Spring**	**Summer**	**Spring**	**Summer**	**Spring**	**Summer**
Dam Counts	1105	694	4215	2608	33855	10709	9854	4355	3296	3260
% Females	41	52	48	40	55	44.5	54.1	53.9	47.8	48.7
# Females	452	361	2023	1032	18620	4766	5333	2346	1539	1588
# Females in Hatcheries	153	100	1036	148	5503	894	2229	365	550	599
Adjustment for Migration Mortality[a]	191	125	1295	185	6879	1118	2786	456	687	749
# Females in Harvest	0	1	20	0	3183	322	643	67	61	36
Female Escapement	261	235	708	847	8558	3326	1904	1823	791	803
Combined Female Escapement	496		1555		11884		3727		1594	
Combined w/n Smolts	161157		599159		1560298		1344382			
# Smolts per Female	325		385		131		361			

[a] Females taken into hatcheries adjusted for a 20% migration mortality.

Table 3. Brood year 1999 Snake River spring/summer chinook salmon hatchery capture data used to estimate percent females and number of females taken into hatcheries.

	Captured (excluding jacks)				Released (excluding jacks)			
Spring Sites	**Total**	**Male**	**Female**	**Unknown**	**Total**	**Male**	**Female**	**Unknown**
Rapid R.	231	84	147	0	7	6	1	0
Oxbow	3	2	1	0	0	0	0	0
Dworshak	130	58	72	0	0	0	0	0
Kooskia	77	45	32	8	8	0	0	8
S. Fk. Clw. R.	16	8	8	0	4	2	2	0
Powell	64	31	33	0	3	1	2	0
Sawtooth	117	82	35	0	76	54	22	0
East Fk.	0	0	0	0	0	0	0	0
Grande R.	1	0	0	1	1	0	0	1
Katherine C.	16	0	1	15	16	0	1	15
Lookingglass	25	14	11	0	0	0	0	0
Lostine	12	5	7	0	12	5	7	0
LGR to Lookingglass	556	318	238	0	0	0	0	0
Totals	**1248**	**647**	**585**	**24**	**127**	**68**	**35**	**24**
% Female			**47.8**	**Est. Females Released = 46 = 35 + (24 X 0.478)**				
<u>**Summer Sites**</u>								
McCall	1218	617	601	0	297	165	132	0
Pahsimeroi	288	132	156	0	123	59	64	0
Imnaha R.	200	126	74	0	99	63	36	0
Totals	**1706**	**875**	**831**	**0**	**519**	**287**	**232**	**0**
% Female			**48.7**					

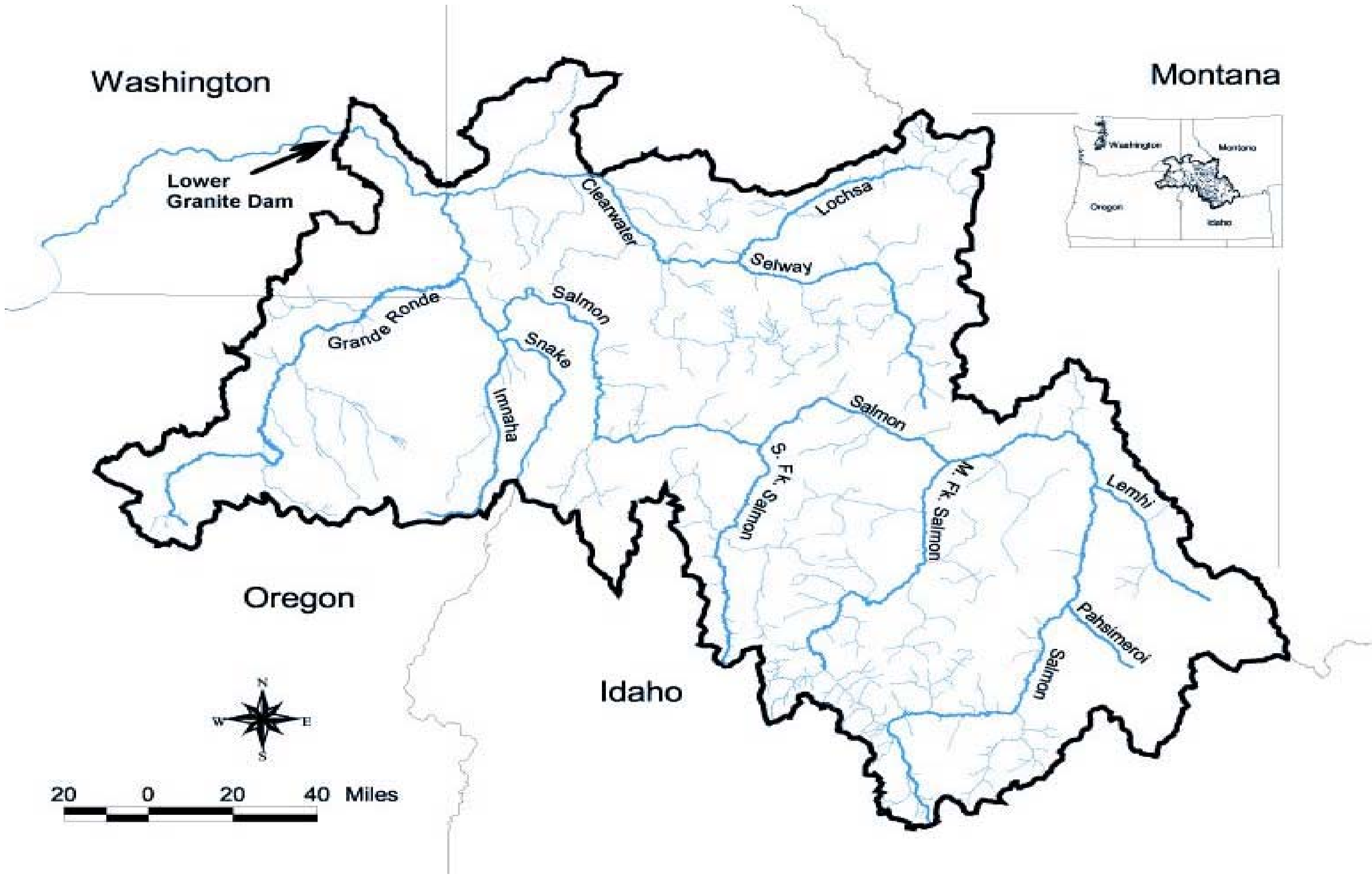

Figure 5. Snake River Basin upstream of Lower Granite Dam that is currently accessible to spring/summer chinook salmon.

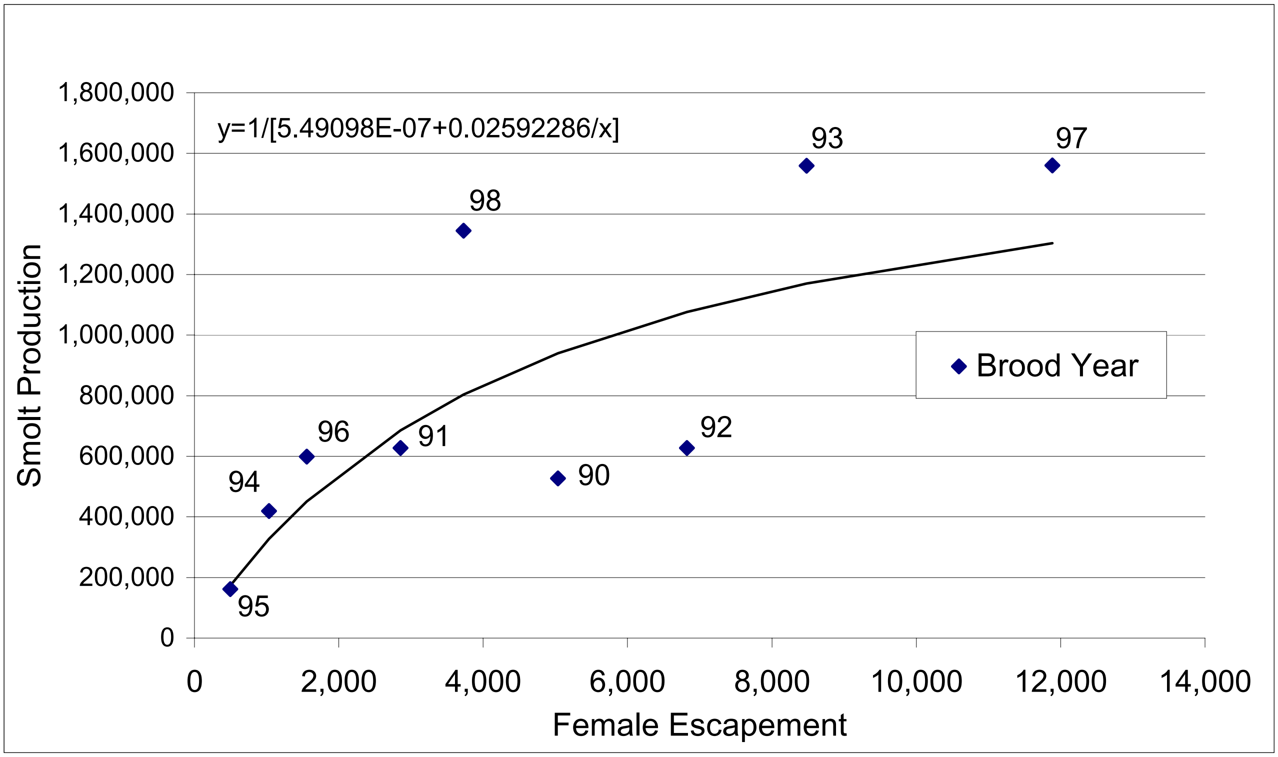

Figure 6. Snake River stock-recruitment relationship for spring/summer chinook salmon, using female escapement as the stock and resulting wild/natural smolt production as the recruits.

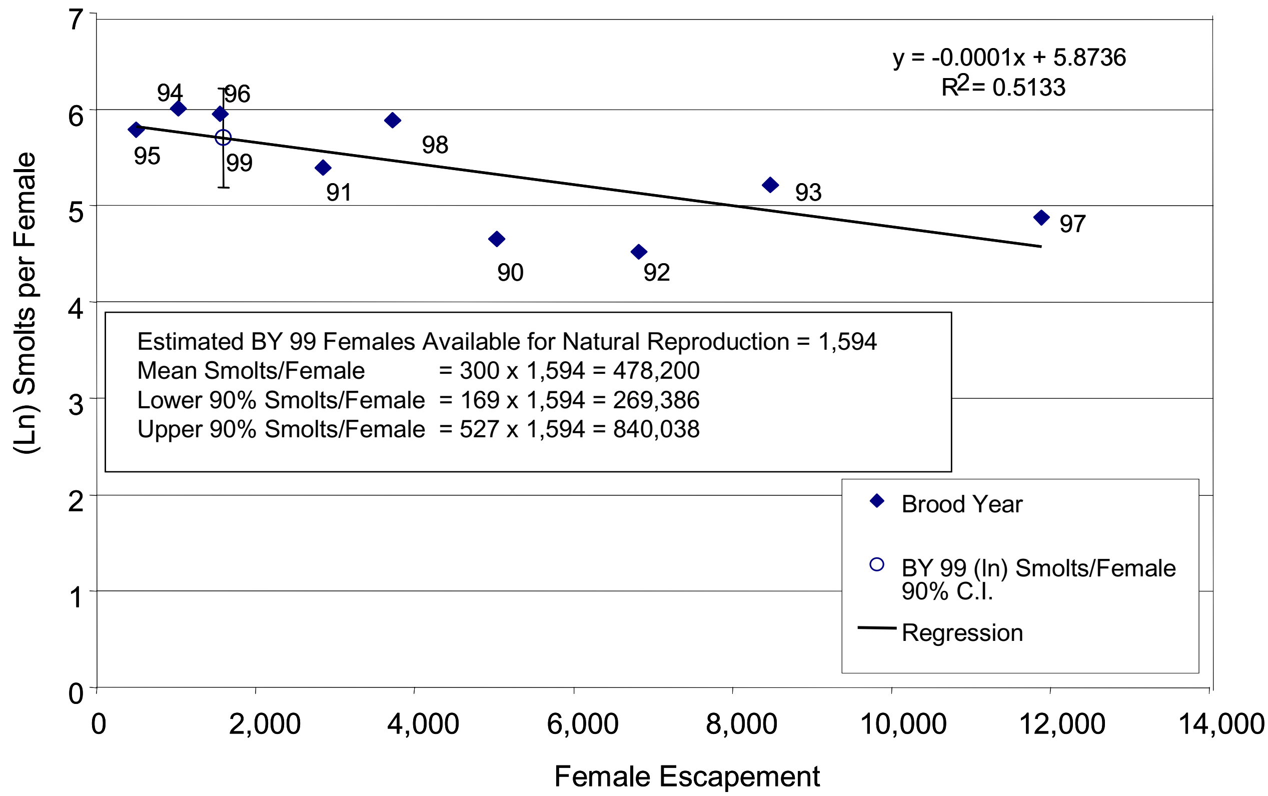

Figure 7. Linear regression of brood years 1990-1998 Snake River spring/summer chinook salmon female escapement and natural logarithmic transformation of resulting smolts per female production, and smolts per female forecast for brood year 1999.

PART 3—IMPROVE WILD STEELHEAD SMOLT-TO-ADULT SURVIVAL RATE INFORMATION BY PIT TAGGING ADDITIONAL WILD STEELHEAD JUVENILES.

ABSTRACT

Beginning in 1998, Idaho Fish and Game's Natural Production Program increased the number of wild juvenile steelhead that were PIT-tagged in the Salmon and Clearwater River drainages. This tagging effort was initiated to increase the precision of SAR estimates for wild steelhead trout. This project tagged steelhead juveniles that were captured by angling with flies during July and August 1999. Other projects increased tagging of juvenile steelhead at existing emigrant traps with tags provided by this project. There were 10,817 steelhead juveniles greater than 124 mm tagged with this effort in migratory year 2000, resulting in 3,404 smolt detections in 2000. The number of adult return detections expected from this effort ranges from three to 23 assuming smolt-to-adult return rates ranging from 0.1 to 0.7 percent.

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INTRODUCTION

Snake River wild steelhead trout *Oncorhynchus mykiss* population declines during the past 25 years have resulted primarily from reduced smolt-to-adult return rates (SARs) (Nemeth and Kiefer 1999). Improving SARs are necessary to recover Snake River wild steelhead trout. Estimating and monitoring SARs is the most effective way to evaluate the effectiveness of hydrosystem mitigation efforts (Ward et. al 1997). The passive integrated transponder (PIT) tag provides an accurate method to estimate SARs for Snake River anadromous fish (Newman, K. 1997). To identify SARs associated with different mainstem migration routes, a larger sample size of PIT-tagged wild steelhead smolts was necessary. Two methods were used to increase the sample size of PIT-tagged steelhead smolts. We provided PIT tags to cooperators of the Idaho Supplementation Studies so that steelhead juveniles captured incidentally to their sampling effort could be tagged. Secondly, angling was used to collect and PIT tag juveniles in streams identified with significant wild steelhead production that were not currently being sampled. This report details PIT tagging efforts in migratory year 2000 (summer 1999, fall 1999 and spring 2000) and the resulting PIT tag detections in 2000 for both efforts.

METHODS

Study Area

Steelhead trout juveniles were caught and PIT tagged in streams of the Salmon and Clearwater River basins (Figure 8). Sampling was concentrated in important wild production areas: Lochsa River basin, Middle Fork Salmon River basin, Salmon River Canyon tributaries, and Salmon River tributaries located downstream from the Salmon River Canyon. All streams were believed to have no or minimal hatchery influence. Streams sampled offered the best combination of access, presumed age-2+ juvenile steelhead densities, and stream size to permit efficient juvenile steelhead collection.

Sampling

Juvenile steelhead were captured by angling with flies from July through August 1999. Previous unpublished work conducted by IDFG demonstrated angling to be a benign and superior collection tool relative to electrofishing and seining in the size and gradient of streams we sampled. Each angler carried a five-gallon bucket to temporarily store captured fish. Water within the bucket was changed at least every 15-20 minutes when fewer than 10 fish were in the bucket and about every 10 minutes when 10 fish or more were in the bucket. Fish were transferred from buckets into 1.0 m x 0.5 m x 0.7 m perforated plastic live-boxes placed throughout the stream until tagged.

Screw traps were placed in the Lochsa and Selway Rivers and operated September through November. Both traps were checked daily, and all juvenile wild/natural steelhead greater than 65 mm in size were PIT tagged and released back into their respective rivers. Any incidental captures of wild/natural chinook were also PIT tagged and released.

PIT Tagging

Fish were PIT tagged at the individual live-boxes for hook and line captured fish and at the trap site for those collected with screw traps. When water temperatures were between 5ºC and 16ºC, fish were anesthetized, and PIT tags were injected into the body cavity using a 12-gauge hypodermic needle and modified syringe. The PIT tags, needles, and syringes were sterilized by soaking in a 70% alcohol solution for at least 10 minutes. Steelhead between 65 mm fork length (FL) and 250 mm FL were tagged with all others being released. Fish were then placed in a live-box and allowed them to recover for at least one hour before being released.

PIT Tag Detection Rates

Detection and tagging information was obtained from the Columbia River Basin PIT-Tag Information System (PTAGIS) database on September 1, 2000. Interrogations reports from all of the four main collector facilities (Lower Granite, Little Goose, Lower Monumental and McNary dams) were used and interrelated with tagging reports to calculate the detection rates of juvenile steelhead. Detection rates for each release site were calculated by dividing the sum of fish detected at one or more of the four main collector facilities by the sum of fish with a length greater than 124 mm tagged at each release site. The date ranges used for determining the season of tagging were Summer: 7/1/99-8/31/99, Fall: 9/1/99-12/31/99 and Spring: 1/1/00-6/30/00.

RESULTS AND DISCUSSION

Steelhead Tagged & Detected

There were 13,416 juvenile *O. mykiss* PIT tagged as a result of this effort during migratory year 2000 (Tables 4, 5, 6, and 7). Eighty-one percent of those tagged (10,817) were greater than 124 mm FL at the time of tagging. Parr less than 125 mm FL usually rear another year in freshwater before smolting (Kiefer and Lockhart 1997). There were 3,404 wild steelhead smolt PIT tag detections from fish that were tagged in migratory year 2000. Overall for migratory year 2000, this effort increased the number of Snake River wild steelhead smolt PIT tag detections from 8,576 to 11,980. Results summarized in this report in regards to cooperators increased tagging efforts will also be reported in their respective program reports.

Juvenile *O. mykiss* actively captured (angling, seining, or electrofishing) and PIT-tagged in rearing areas during the summer have lower average detection rates than juveniles captured and tagged during the same period with emigrant traps (Byrne, A. 2001). *O. mykiss* greater than 124 mm in fork length that were actively captured (angling) and tagged in their rearing streams during summer 1999 had detection rates that averaged approximately 6.4% (Table 4), while juveniles captured with emigrant traps during the summer 1999 averaged 41.8% (Table 5). We believe the increased rate observed for traps is a result of capturing juvenile steelhead beginning their seaward migration. Juveniles captured with active methods include steelhead that will rear another year before smolting and resident rainbow trout. Some of the streams fished (such as Wind River) may have a greater proportion of resident rainbow trout.

The Idaho Natural Production Monitoring and Evaluation Program will therefore move efforts from these streams with low detection rates to other significant steelhead production streams.

Low smolt-to-adult survival will continue to limit adult detections in the foreseeable future. As a result, we will adjust the locations sampled and capture methods used to increase the number of smolt detections. Any adjustment in locations will be made while maintaining our goal of tagging juvenile *O. mykiss* from important wild steelhead production sub-basins that are under represented by other research projects' PIT-tagging efforts (Appendices A & B). Fish captured by emigrant traps were detected at a higher rate than juveniles captured by angling in summer rearing areas (Table 4, 5 & 6). Consequently, we may shift to emigrant trapping in streams where we collect fish with summer angling that are logistically suitable for trapping. Summer angling will continue in those streams where the use of emigrant traps is not feasible.

ACKNOWLEDGMENTS

We greatly appreciate the Idaho Natural Production Monitoring and Evaluation Program tagging crew (James Gilbert, Josh Carpenter, Darrin Beckley, and Andy Gilbert) for their outstanding effort to collected and tag wild *O. mykiss* juveniles in some of the most difficult streams to access and work in. We thank the following IDFG project leaders and their field crews who cooperated with the PIT tagging effort: Kim Apperson, Jody Brostrom, Alan Byrne, and Tom Curet. Special thanks go to the Nez Perce Tribe and the U.S. Fish & Wildlife Service for cooperating with this effort as well.

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Table 4. Steelhead actively collected (angling) and PIT tagged in the summer of 1999 and detected in 2000.

Stream	No. Tagged >124 mm FL	No. Detected >124 mm FL	Detection Rate	No. Tagged Total	Cooperators
American River	1	0	.000	3	ISS
Bargamin Creek	501	108	.216	567	NP
Camas Creek	24	3	.125	24	NP
Chamberlain Creek	1,334	285	.214	1,375	NP
Chamberlain Creek	849	212	.250	1,347	ISS
Crooked Creek	134	22	.164	156	ISS
Horse Creek	463	77	.166	552	NP
Johns Creek	8	0	.000	9	ISS
Johnson Creek	21	4	.190	36	ISS
Lake Creek	20	2	.100	23	NPT
Lick Creek	491	52	.106	621	ISS
Rapid River	56	8	.143	56	NP
Slate Creek	523	62	.119	589	NP
Storm Creek	702	74	.105	768	NP
Tenmile Creek	40	3	.075	48	ISS
White Sands Creek	282	28	.099	22	NP
Wind River	312	4	.012	332	NP
Total	**5,761**	**944**	**.164**	**6,528**	

Table 5. Steelhead passively collected (emigrant trap) and PIT tagged in the summer of 1999 and detected in 2000.

Stream	No. Tagged >124 mm FL	No. Detected >124 mm FL	Detection Rate	No. Tagged Total	Cooperators
Crooked Fork Creek	86	40	.465	137	ISS
Crooked River	3	0	.000	3	ISS
Fish Creek	598	320	.535	598	SSS
Marsh Creek	43	19	.442	255	ISS
Pahsimeroi River	83	11	.133	101	ISS
Red River	2	0	.000	54	ISS
Secesh River	28	8	.286	28	NPT
South Fk. Salmon River	225	50	.222	338	ISS
Upper Salmon River	3	1	.333	5	ISS
White Sands Creek	14	5	.357	16	ISS
Total	**1,085**	**454**	**.418**	**1,535**	

Note: Cooperators Key: ISS-Idaho Supplementation Studies, NP-Natural Production, NPT-Nez Perce Tribe, SSS-Steelhead Supplementation Studies USFWS-United States Fish & Wildlife Service

Table 6. Steelhead passively collected (emigrant trap) and PIT tagged in the fall of 1999 and detected in 2000.

Stream	No. Tagged >124 mm FL	No. Detected >124 mm FL	Detection Rate	No. Tagged Total	Cooperators
American River	47	18	.383	51	ISS
Crooked Fork Creek	138	82	.594	139	ISS
Fish Creek	2,402	1,409	.587	2,402	SSS
Lake Creek	68	8	.118	79	NPT
Lochsa River	210	96	.457	213	NP
Marsh Creek	24	3	.125	25	ISS
Pahsimeroi River	165	28	.170	224	ISS
Red River	16	3	.188	29	ISS
Secesh River	74	8	.108	80	NPT
Selway River	55	17	.309	63	NP
South Fk. Salmon River	170	73	.429	176	ISS
Upper Salmon River	10	1	.100	12	ISS
White Sands Creek	18	9	.500	18	ISS
Total	**3,397**	**1,755**	**.517**	**3,511**	

Table 7. Steelhead passively collected (emigrant trap) and PIT tagged in the spring of 2000 and detected in 2000.

Stream	No. Tagged >124 mm FL	No. Detected >124 mm FL	Detection Rate	No. Tagged Total	Cooperators
American River	21	11	.524	681	ISS
Clear Creek	218	127	.583	228	USFWS
Crooked Fork Creek	71	45	.634	125	ISS
Crooked River	2	0	.000	57	ISS
Lake Creek	17	1	.059	60	NPT
Marsh Creek	31	1	.032	32	ISS
Pahsimeroi River	247	97	.393	253	ISS
Red River	25	16	.640	172	ISS
Secesh River	7	0	.000	206	NPT
South Fk. Salmon River	60	38	.633	60	ISS
Upper Salmon River	9	3	.333	10	ISS
White Sands Creek	57	39	.684	58	ISS
Total	**765**	**378**	**.494**	**1,714**	

Note: Cooperators Key: ISS-Idaho Supplementation Studies, NP-Natural Production, NPT-Nez Perce Tribe, SSS-Steelhead Supplementation Studies USFWS-United States Fish & Wildlife Service.

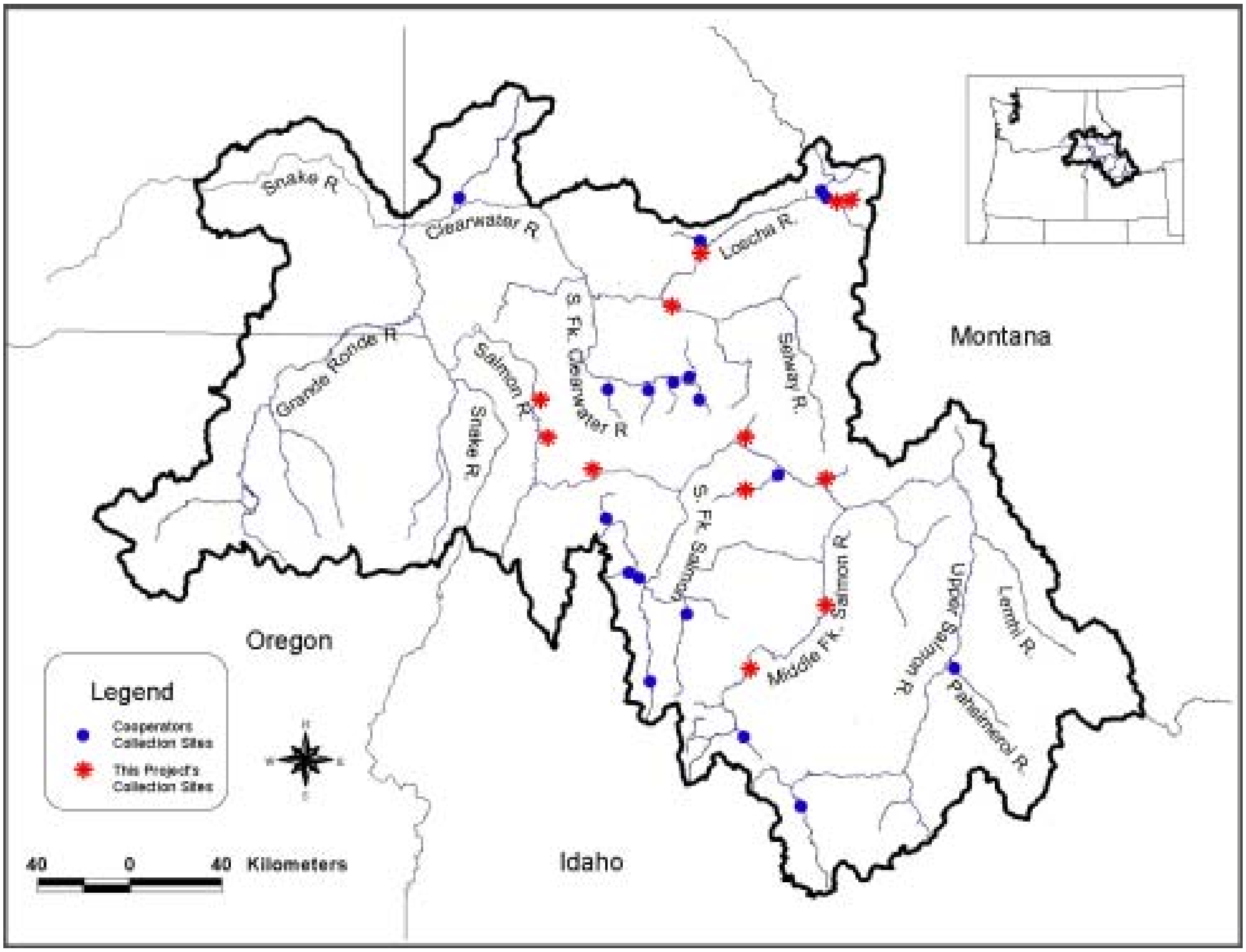

Figure 8. Snake River Basin study area and rearing streams from which juvenile steelhead were collected and PIT tagged.

APPENDICES

Appendix A. Considerations and Recommendations for Future PIT Tagging Efforts

1. The utilization of two crews of two or three people per crew angling in different areas of a stream has the potential to result in dramatically increased capture rates. The number of steelhead captured in 1999 appeared to be somewhat independent of crew size. This is attributed to the logistics of angling and transporting fish in the streams fished. Of the streams fished during 1999, Bargamin Creek, Chamberlain Creek, Storm Creek, White Sand Creek, and Slate Creek could be fished with two crews fishing simultaneously. Over a six-day period, about four to eight miles could be fished depending upon the size of the stream system, accessibility, and fish abundance. On average, an experienced angler could catch 60-90 fish in five to six hours depending upon fish densities.

2. In selecting streams to sample, we first identified important wild steelhead production sub-basins (CBFWA, 1991) that were underrepresented by other research projects' PIT tagging efforts. For each of the identified sub-basins, streams to sample were selected based on the following criteria: representative of sub-basin, observed juvenile *O. mykiss* densities, and stream characteristics suitable for efficient collection. Based on fish density, total number of fish present, and detections in 2000, streams to be fished in the future, in priority order, are: Chamberlain Creek, Bargamin Creek, Horse Creek, Slate Creek, and Storm Creek.

3. The time of year when streams are fished is critical to angling efficiency to avoid high flows and ensure capture of steelhead before emigration. For instance, lower Chamberlain Creek was entered too early (third week in July) for maximum angling efficiency due to high flows, and Slate Creek densities were dramatically reduced in late August to early September relative to densities in the first week of August. Considering basin-specific runoff patterns, emigration, and densities, it is recommended that priority streams be fished in the following relative order from first to last: Storm Creek, Slate Creek, Bargamin Creek, and Chamberlain Creek.

4. Each stream maintained its unique challenges for catching fish; however, some generalizations can be made. Low gradient stretches tended to yield low catches, whereas higher gradient, step-pool reaches yielded the best catches. Fishing was best from 12:00 p.m. to 8:00 p.m. Pacific Standard Time. Steelhead were less active before 12:00 p.m. and would not readily strike a fly. If fishing in the morning was unavoidable, either a green Stimulator or a small nymph worked best. Dry flies sized 10 and 12 were most effective. Fly patterns in order of preference were green/orange Stimulators, Royal Wulffs, Irresistible Wulffs, and yellow/red Humpies. Flies that had some white on them were highly visible to the angler and hence easier to use. In some areas small red, green, and black nymphs were used to catch fish that were not feeding on the surface. Fly-tying material should be included in the crew's equipment so particularly effective flies could be tied and customized in the field.

5. Wind River in the lower Salmon River canyon was briefly scouted and had high densities of steelhead in mid-August, but detection rates were less than 10%.

6. Another comparison of capture between electrofishing and angling should be considered in an effort to improve collection efficiency. Initially smaller streams with good access should be targeted. Slate Creek and Colt Creek would be two candidate streams.

7. Steelhead seemed to be calmer when placed in dark (green or black) buckets as opposed to white buckets.

Appendix B. Stream specific comments by system.

LOCHSA RIVER SYSTEM

Colt Killed Creek (formerly White Sand Creek)

Dates fished: July 26 - 27

Colt Killed Creek was one of the largest systems this project fished. The highest yields of fish were caught about three miles above the mouth of Colt Creek. Downstream from the mouth of Colt Creek water levels were very high and difficult to fish. This section might be very productive with lower stream flows.

Habitat at the mouth of Colt Killed Creek was characterized by pocket-water and had low steelhead densities.

Storm Creek

Dates fished: July 21 - 25

Storm Creek is a tributary of Colt Killed Creek. It is located about 3.7 kilometers downstream from the Colt Creek Cabin and can be reached by walking down Colt Killed Creek to the mouth or via the Colt Killed Creek trail which leads to the upper-middle portion of Storm Creek. Due to the length of the Colt Killed Creek trail, horses would be preferred to carry equipment. Lower Storm Creek flowed through a steep canyon and large amounts of woody debris in the channel made walking difficult. The lower three miles of Storm Creek were fished. Densities in this reach may have been the highest of any stream fished. In the future, an entire six days should be allocated to fishing Storm Creek. Efficiency would be improved if one group of anglers fish upstream from the mouth and another group accesses the creek by the trail and fish downstream.

MAINSTEM SALMON RIVER SYSTEM

Chamberlain Creek

Dates fished: Aug 4 - 10

Chamberlain Creek is a tributary of the Salmon River and enters the mainstem Salmon in the Salmon River canyon. The tagging crew was transported to Chamberlain Creek via a jet boat driven by an IDFG conservation officer. The creek was fished from the mouth to about one mile downstream of McCalla Creek. Stream flow was high and fishing efficiency was impaired. It is expected that many more steelhead could be captured and tagged at lower flows. Sixteen rattlesnakes were encountered while walking the Chamberlain Creek trail.

On August 22, two individuals flew into the Chamberlain Creek airstrip and fished mainstem Chamberlain Creek downstream from the mouth of West Fork Chamberlain Creek. Densities and catch rates were quite high approximately 0.75 miles below the mouth of the West Fork of Chamberlain Creek. The next two miles of stream were dominated by pocket-water and had low densities of steelhead. All significant pools yielded at least one or two steelhead, however. Overall, densities were high enough to justify the effort.

Bargamin Creek

Dates fished: August 18 - 21

Bargamin Creek is a Salmon River tributary and enters the river about 113 kilometers upstream from Riggins, Idaho. One group of four anglers fished the lower three miles, and a second group of three anglers fished from the end of forest road 468 downstream 16 kilometers. A trail runs along much of the length of the stream.

A commercial jet boat operator took the four-person crew beginning at the mouth from Mackay Bar to Bargamin Creek and back. The cost for the commercial operator was about $1,200.

It is also noted that Bargamin Creek had relatively high densities of steelhead dispersed over about 15 miles of stream.

Horse Creek

Dates fished: August 22 - 24

The Horse Creek drainage drains into the Salmon River upstream of Bargamin Creek. It is accessed by jet boat and worked on during the Bargamin Creek trip. The stream is bordered by a well-maintained trail and is easily accessible. The crew begins at the mouth and works up approximately 3-6 miles.

Slate Creek

Dates fished: July 8 - 11

Slate Creek drains into the Salmon River about 19 miles north of Riggins. The first four or five miles are in private ownership and were not fished. The stream from the U.S. Forest Service boundary upstream to about 2.5 miles above North Fork campground was fished. Above that, Slate Creek widens and becomes very shallow. The road runs along the entire system and allows for easy access. Warm water limited the amount of time available for tagging during daylight hours. Algae on the streambed and a steep and brushy riparian area made walking and casting difficult.

Wind River

Dates fished: July 12 - 13

The Wind River drains into the Salmon River upstream from the city of Riggins. Access to the mouth of the river is good, but moving up along the stream quickly becomes increasingly more difficult upstream of the mouth. There is no trail along the steam, making access difficult. The stream is characterized by steep gradient with many plunge pools all within a thick canopy of pines. Fish densities and collection rates were high, but based on the PIT tag detection rates (Table 4), it appears that the majority of the population is resident rainbow trout. We therefore do not plan to collect and tag in this stream in the future.

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